PART 7

GENERAL INSTRUMENTATION CONROL AND AUTOMATION WORKS

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7 General Instrumentation Control & Automation Requirements

7.1 Introduction

This part covers the general requirements for the design, supply, installation, inspection and testing of the Instrumentation, Control and Automation and associated plant and materials for STP .On a minimum, plant under this contract shall be provided with the individual instrumentation, control and automation equipment as detailed under the general and particular requirements.

7.2 Reference Standards

Unless otherwise approved, all equipment shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

Generally, the following latest edition of codes and standards prevailing at the time of award of contract shall be applicable.

7.2.1 Temperature Measurement

a) Instrument and apparatus for temperature measurement - ASME PTC 19.3 (1974).
b) Temperature Measurement - Thermocouples - ANSI - MC 96.1 - 1982.
c) Temperature Measurement by electrical resistance thermometers – IS : 2806
d) Thermometer-element-Platinum resistance - IS: 2848 / DIN 43760

7.2.2 Pressure Measurement

a) Instrument and apparatus for pressure measurement - ASME PTC 19.2 (1964).
b) Bourdon tube pressure and vacuum gauges - IS: 3624/1996.

7.2.3 Flow Measurement

a) Instruments and apparatus for flow measurement - ASME PTC 19.5 (1972) Interim supplement, Part-II
b) Measurements of fluid flow in closed conduit - BS 1042.

7.2.4 Electronic Measuring Instruments and Control Hardware

a) Automatic null balancing electrical measuring instruments -ANSI C 39.4 (Rev. 1973), IS 9319
b) Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 / 1974.
c) Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1 / 1975.
d) Dynamic response testing of process control instrumentation - ANSI MC 4.1 (1975) - ISA -S26 (1968).
e) Surge withstand capability (SWC) tests - ANSI C 37.90A (1989), IEC-255.4.

7.2.5 Instrument Switches and Contacts

a) Contact Rating - AC services NEMA ICS Part-2 125, A-600
b) Contact Rating - DC services NEMA ICS Part-2 125, N-600

7.2.6 Enclosures

a) Enclosures for Industrial Controls and Systems–NEMA ICS-6-110.15 through 110.22
b) Racks, panels and associated equipment -EIA: RS-310-B-1983 (ANSI C83.9 - 1972).

7.2.7 Apparatus, Enclosures and Installation Practices in Hazardous Area

a) Classification of hazardous area - NEMA Article 500, Volume-6, 1978.
b) Electrical Instruments in hazardous dust locations - ISA-RP 12.11.
c) Intrinsically safe apparatus - NFPA Article 493 Volume-4 1978.
d) Purged and pressurized enclosure for electrical equipment in hazardous location
e) - NF Article 496 Volume-4, 1978.

7.2.8 Sampling System

a) Stainless Steel material of tubing and valves, for sampling system - ASTM A269-79 GRTO-316.
b) Submerged helical coil heat exchangers for sample coolers -- ASTM D11-98.

7.2.9 Annunciators

a) Specifications and guides for the use of general-purpose annunciators - ISA RP 18.1.
b) Surge withstand capability tests -ANSI C37.90 a -1971 and IEEE Standard 472- 1974

7.2.10 Interlocks, Protections

a) Relays and relay system associated with electric power apparatus - IEEE Standards 3.13.
b) Surge withstand capability tests - ANSI C37.90 a - 1971 and IEEE Standard 472-1974.
c) General requirements and tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I)/1973.

7.2.11 UPS System

a) Practice and requirements for semi-conductor power rectifiers - ANSI C34.2.
b) Relays and relay systems associated with electrical power apparatus IEEE Standard - 3.13.
c) Surge withstand capability tests - ANSI C 70.90 A/1971, IEC-255.4.
d) Recommended practice for sizing large lead storage batteries for generating stations and sub-stations - IEEE-485.
e) Ni-Cd Battery - IEEE Std. 1106 /IS 10918

7.2.12 Instrument Tubing

a) Seamless Carbon Steel Pipe - ASTM-A-106.
b) Forged carbon steel fittings - ASTM-A-105.
c) Dimensions of fittings - ANSI-B16.11.
d) Code for pressure piping, welding, hydrostatic testing - ANSI-B 31.1.
e) Nomenclature for instrument tube fittings - ISA-RP 42.1 / 1982.
f) Seamless Stainless Steel Tube ASTM A-213 TP 316 / ASTM A-269 TP 316
g) Seamless Alloy Steel Pipe ASTM A 335 P22
h) Seamless Stainless Steel Pipe ASTM A-312 TP 316

7.2.13 Cables

a) Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy-IPCEA S-61-402

b) Guide for design and installation of cable system in power generating station (insulation, jacket materials) - IEEE Standard 422.
c) Requirements of vertical tray flame test - IEEE 383
d) Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B33.

7.2.14 Electronic Cards, Subassemblies and Components

a) Unpackaged

i. Vibration	:	IEC-68.2.6
ii. Shock	:	IEC-68.2.27
iii. Drop & Topple	:	IEC-68.2.31

b) Packaged

Vibration, Drop & Static Compression - NSTA.

c) Electromagnetic Compatibility

i. Electrical Fast Transient	:	IEC-801.4
ii. Surge Withstand	:	IEC-255.4
iii. Radiated Electromagnetic Field	:	IEC-801.3
iv. Electrostatic Discharge	:	IEC-801.2
v. Electromagnetic Emissions	:	VDE 0871, Class-B

7.2.15 Cable Trays, Conduits

a) Guide for the design and installation of cable system in power generating station (cable trays, support systems, conduits) - IEEE Standard 422, NEMA VE-1, NEC-1981. Test Standards NEMA VE-1-1979.
b) Galvanizing of carbon steel cable trays - ASTM A-386.

7.2.16 Characteristics

1) ISO 9000 and 09004	-	Quality Systems
2) IEEE 587	-	Power Supply Surge Protection\
3) IEC 61158-2	-	Communication Protocols
4) ISO 9075 (BS 6964)	-	Structured Query Language (SQL)
5) BS 5515	-	Documentation of Computer Based Systems
6) BS 7165	-	Recommendation for Achievement of Quality in Software
7) BS EN 50081	-	Electromagnetic Compatibility
8) ISO 3511	-	Process measurement control functions – Instrumentation symbolic representation
9) ISO-OSI	-	7 Layer Communication Model
10) IEEE 472-1974	-	Surge protection.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Employer Representative for consent before any design against that standard proceeds.

7.3 Documents to be submitted by the Bidder during Bid Submission for technical bid qualification for Instrumentation Control & Automation

Note: In addition to the below information to be submitted, the technical schedule shall be completed in full for technical bid qualification. Bidder to note the importance of this requirement.

1. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
2. Provide a written overview of the proposed control & instrumentation system describing the principal functions and capabilities of the entire system (PLC based SCADA) for STP, system communications, Software & hardware, integration and general system capabilities as required under the general & particular requirements of ICA.

3. Provide written description of the Fire alarm, detection and suppression system and its integration with the plant PLC based SCADA system.

4. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all hardware & software items. List shall include as a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for instruments, PLC & SCADA, and all other equipment shall be duly filled with all relevant details without any deviations with the bid requirements. The technical schedule shall be completed in full for technical bid qualification. Bidder to note the importance of this requirement.

5. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner.
   Note: Proprietary software will not be accepted.

6. Technical details are required for the following without any deviation as per bid requirements:
   - Name and version of the proposed SCADA software Package.
   - Name and version of the PLC on-line/off-line programming software for all controllers, inclusive of vendor supplied systems (if any).
   - Name and version of the PLC,
   - Name and version of the PLC I/O Modules,
   - Name and version of Historian software
   - Name and version of any required communications software, firmware, etc.
   - Name and version of the specified report application software,
   - Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
   - Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
   - Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
   - Submit resumes of ICA engineers who will be in charge of design of works as required under this contract. The ICA engineer who shall be in charge of design of works from the contractor, shall have minimum of 10 years' experience of having designed, executed & completed PLC based SCADA systems for STP's as required under this contract.
   - Above documents shall be submitted in proper bounded form and indexed with page numbering for easy referencing. All catalogs and literature (including sub-suppliers' catalogs), datasheets,

Instrument list, etc. shall be bounded together in indexed volumes. The Contractor shall submit all the documents with indexing with page numbering for easy reference

Note: The Contractor shall provide all of the above required details/documents as qualification criteria during the bid submission. Failure to do so will be treated as a non-responsive bid *and lead to technical disqualification.* The Contractor should note the importance of the obligation.

7.4 Project Requirements

1) Contractor shall provide material, equipment & services specified or otherwise required to fulfill the intent of specification and to integrate into a fully functional Instrumentation and Control system ensuring operability, maintainability and reliability and durability for operation & maintenance period of seven (7) years described in this specification.

2) Contractor shall furnish their offer based on the requirements as described in the specification.

3) The scope of supply shall include but shall not be limited to the following:

a) Field instruments and sensors for remote measurement, Primary flow elements along with branch pipes, root valves, nipples, flanges, nuts, bolts, gaskets and accessories.
b) Instrumentation pair, triad & core cable, instrumentation power cable, optical fiber cable, special cable etc, cable trays. as required.
c) Control panel, panel instruments, field junction boxes, instrument enclosures accessories and furniture (system consoles), as required.
d) Required power supply
e) Supply of all start-up, commissioning and recommended spares in addition to the mandatory spares.

4) Contractor shall provide local panels for local start/stop/E-Stop monitoring of auxiliaries and equipment's as per the requirements to be decided during detail engineering stage. Ingress protection of panels shall be as per requirements mentioned in this document.

5) Local Panels, Gauge Boards and Transmitter Racks, stanchions, brackets etc. as required.

6) Process connection and piping materials including impulse pipes of different grades & stainless steel tubes, stub, bosses, root valves, isolation & drain valves, valve manifolds, gauge valves, condensate pot, fittings, stands, brackets etc. as applicable, for satisfactory installation of all field instruments and analysers.

7) Pneumatic tubing along with fittings and isolating cocks for air consumers.

8) Erection hardware including junction boxes, canopies, field enclosures for all instrumentation,structural steel items viz steel angles, channels, flats.

9) Complete cable accessories viz flexible conduits, sub-trays/perforated trays, pull boxes, inspection covers, bends, elbows, mounting brackets, clamps, nuts and bolts, glands, lugs, ferrules, connectors, markers, tray supports, rigid conduits, tie wraps etc.

10) Complete optical fiber cable /special cables with accessories like optical fiber distribution box, patch cord / pigtail, converter, terminators, taps, heavy duty conduits etc. to make the system complete in all respect.

11) Rating plates, Nameplates and Labels.

12) Maintenance, calibration, commissioning, site testing and troubleshooting equipment.

13) Fiber optic cable and accessories including tray /conduit for system data network and for data collection through Modbus, Ethernet or OPC connectivity, wherever required.

14) Arranging all performance test instruments and equipment.

15) Instrument control panels.

16) Performing tests on all equipment as per Quality Plan prior to shipment.

17) Contractor shall be responsible for software licensing, design, development, debugging, system engineering, customizing, installation, site modification, tuning, adjustments, commissioning and furnishing manuals, documentation etc.

18) Drawings and Documents: Contractor shall furnish system description, operational write-up, bill of materials, drawings, data, information, technical catalogues, test certificates and other details to establish the provenness, capability and performance of the equipment and systems offered.

19) Final Drawings

a) Contractor shall secure approval on the design drawings from Employer for the drawings identified as "Approved", in writing. Any manufacture done prior to approval of the drawings shall be rectified in accordance with the approved drawings by Contractor at his own cost and time and the equipment shall be supplied within the stipulated period.
b) Contractor shall furnish final drawings and documents in multiple (3 sets) hard and soft copies. Contractor shall furnish instruction manuals containing various components, sub-assemblies, method of installation, check-ups and tests to be carried out during erection and commissioning of the equipment. The manual shall also include instruction for step checking, trouble shooting and fault rectification for different components and sub-assemblies.
c) Contractor shall incorporate all modifications in the drawings carried out at site during trial run, start-up performance and guarantee tests till hand over of the units to Employer and submit these final as-built drawings both in hard and soft copy.
d) Final documents shall be submitted in proper bounded form. All catalogs and literature (including sub-suppliers' catalogs), datasheets, Instrument list, input output list, function control diagram, loop diagrams, configuration diagram etc. shall be bounded together in indexed volumes. All O&M manuals shall be in handy size and neatly bound for carrying it to the work place.
e) Contractor shall convert all drawings and documents, manuals under this contract in to PDF format and store it in operator work station at the SCADA control room.
f) Operation and maintenance instructions
1) Composite manual describing the functional and operation of each piece of equipment.
2) Composite manual for testing and servicing every system and individual item.
g) Original manuals and CDs from OEMs.
h) Training material shall be provided which shall include the presentations used for trainings and also the required relevant documents for the topics.

1) The selected Contractor shall submit a complete set of
2) Floor Layout Drawings,
3) Single Line diagram.
4) Complete cabling system layout (as installed), including cable routing.
5) The layout shall detail locations of all components and indicate all wiring pathways.
i) The Contractor shall be responsible for preparing process documentation related to the operation and maintenance of each and every component of the Instrumentation, control & Automation system.

j) The prepared process document shall be formally signed off by end user before completion of final acceptance test.
k) The Contractor shall document all the installation and commissioning procedures and provide the same to end user, within one week of the commissioning of project along with final configuration dumps and implemented solution details.
l) The Contractor shall be responsible for documenting configuration of all devices and keeping back up of all configuration files, so as to enable quick recovery in case of failure of devices.

7.5 Qualification Criteria for Instrumentation agency, Control & Automation agency, Lab equipment agency for design, supply, program, execution and commissioning of works

The contractor shall submit the following documentation for review and approval, as part of credentials submissions of the agency, for design, supply, program, execute and commission the works to the Employer Representative, before commencing any design ,supply or associated works. Only on the approval of the same, the contractor shall commence the design and other associated works. Contractor shall note the importance of this clause.

Note-1: The contractor shall note that the approved vendor list indicated in particular requirements for Instrumentation, control and automation, is only for the product make indicated.The contractor shall submit the credentials of the agency which shall be supplying & executing (design, supply, program ,execute and commission) the work for review and approval as per qualification criteria indicated below. The agency/OEM for design, supply, program, execute and commissioning the works, shall comply in all aspects with the qualification criteria as indicated below on a minimum.

Note-2: There shall be a single agency which shall design, supply, program, execute and commission the works to ensure uniformity among equipment and spare holding.

Instrumentation:

The agency on a minimum shall be operating under an accredited ISO 9001:2015 systems.

The agency should have minimum 10 years of experience in India in the field of instruments supply, installation, commissioning and operation and maintenance of instruments in plants as required under this contract, within India and shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution. The agency shall be an authorized channel partner for the instrumentation equipment for minimum three years continuous period. Verification certificates signed not less than the country head of OEM shall be submitted.

The agency shall have executed & completed at least ten STP project within India during the last ten years period, inclusive of supply, installation, commissioning and operation and maintenance period of minimum 1 year within India.

Control & Automation:

The contractor shall submit the following documentation as part of credentials submissions for the control & automation agency for design, supply, and program, execute and commission the works.

The agency which shall design, supply, program ,execute and commission control and automation equipment, on a minimum **,** shall be operating under an accredited ISO 9001:2015 system ,with a minimum of 10 years' experience of having designed, executed & completed PLC based SCADA systems

for STP's, inclusive of supply, installation and commissioning; and operation and maintenance period of minimum 1 year on a single facility within India during the last five years and shall demonstrate capability and resources for integrating/ interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.
The agency shall be an authorized channel partner for the named PLC hardware & SCADA software for minimum of 5 years on a continuous basis till date. Verification certificates signed not less than the country head of OEM shall be submitted. The agency proposed personnel shall be trained on a yearly basis by the product OEM on the proposed control system. Agency shall submit documentation to validate the same as part of credentials submission. Verification certificates signed not less than the country head of OEM shall be submitted.

The agency shall demonstrate in house FAT facility with FAT simulation panel and other required hardware and software to conduct FAT as required under this contract. Agency shall submit documentation to validate the same as part of credentials submission.

The Agency on a minimum, shall have executed & completed at least ten individual STP contracts for complete control and automation each, out of which, at least three STP's shall be of minimum 40 MLD or more within India during the last five years period. Verification end user performance certificates shall be submitted for the same.
Note: In the event, if the OEM intends to execute (design, supply, program, execute and commission) the works, the OEM shall comply in full to the qualification criteria as required in this clause & specification.

The agency shall have a Automation manager with minimum fifteen years of relevant experience and at least two team leaders with minimum seven years of relevant experience. The agency shall have minimum five number of design engineers with at least three years of relevant experience in design, installation and Commissioning of works similar to this contract and overall capacity and process. The engineers shall be on its permanent employment. Proof of ESIC/PF should be submitted to demonstrate the permanent employment. (Associate Employer Representatives/ Advisers/ consultants shall not be considered).The agency shall submit documentation and signed resumes of the personnel as part of credentials submission. The contractor and agency shall depute only approved personnel, who's resume has been approved.

Lab Equipment

The agency shall be operating under an accredited ISO 9001-2008 or above Quality System on a minimum.

The agency shall be an authorized channel partner for the equipment.

The agency shall have executed & completed at least five projects for setting up of STP /drinking water lab & testing facility within India in Public sector units/Govt. agencies during the last three years period, inclusive of supply, installation, commissioning of the laboratory equipment. Verification end user performance certificates shall be submitted for the same.

7.6 Design Submissions to be submitted by the contractor during the contract period:

1) The Contractor shall make submissions to the Employer Representative of all design drawings, schedules and complete documentation on spare parts relating to instrumentation and control equipment and systems provided under this Contract.
2) These submissions shall include, the following on a minimum :

A. P&ID

a) Process and instrumentation diagram shall be as per ISA 5.1 latest release. The P&ID shall contain the following on a minimum and in sequence:

1) Legend sheet inclusive of process line abbreviations, line designation, process designation, symbols of all equipment, etc.
2) Tag Identification system. (Note: The tagging philosophy shall be submitted before the submission of the P&ID for review and approval before the tag i.e. is incorporated in the P&ID.)
3) Typical Signal interface sheet
4) Process & Instrumentation sheets as per each process, which shall depict the interlock sequence for each equipment & process operation. The interlock sequence shall be depicted by using interlock numbering next to the equipment/process.
5) Interlock sheet detailing every interlock for the system (Pumps, drives, blowers, valves, etc.). For e.g.: Start, Stop, Trip, sub process sequence, etc.
6) Each P&ID shall be submitted along with the process control philosophy.
7) The above requirements are also applicable for vendor supplied systems P&ID.

B. Instrumentation

a) Functional design specification (FDS) The Contractor shall submit a complete functional Design specification (FDS) for approval by the Employer Representative within five (5) months of the award of the Contract. The Contractor should take note of the importance of this clause.

The functional design specification shall be submitted for the following

b) The contractor shall submit the instrumentation schedule based on code-A approved P&ID.
c) Instrument schedule shall be submitted and approved before the submission of Instrumentation FDS.
d) The FDS shall include on a minimum, Instrument datasheets,Instrument location layouts, OEM product brochure, Instrument hook up diagrams and quality Assurance plan for functional testing & inspection at the factory where the equipment has been manufactured, spare part list, spare parts availability letter from the OEM and service support from authorized agencies, shall provide list of service agencies authorized for the same.
e) General arrangement drawings of field-mounted instruments showing installation details.
f) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
g) Layout drawings of panel fascia's showing instruments, controls and details of all labels.
h) Internal circuit and wiring diagrams for instrument and control panels.
i) Schematic control diagrams.
j) Instrument loop diagrams.
k) Instrument wiring and piping diagrams.
l) Interconnection wiring diagrams.
m) Cable block diagrams, drawings and schedules.
n) Instrument system and panel power distribution diagrams.
o) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
p) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
q) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

C. Control & Automation

1) Functional design specification (FDS) The Contractor shall submit a complete functional Design specification (FDS) for approval by the Employer Representative within five (5) months of the award of the Contract. The Contractor should take note of the importance of this clause. The functional design specification shall be submitted .
2) This document shall serve as the primary mechanism by which the Employer Representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements.
3) On a minimum, FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Flow charts shall be used to depict the control philosophy along with the write up for the same.
4) Proposed SCADA screens shall be an integral part of the submissions.
5) The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal.
6) The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
7) The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
8) Drawings and schedules as part of FDS (For both Instrumentation & Control & Automation):
9) General arrangement drawings of field-mounted instruments showing installation details.
10) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
11) Layout drawings of panel fascias showing instruments, controls and details of all labels.
12) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
13) Annunciator arrangement and engraving details.
14) Internal circuit and wiring diagrams for instrument and control panels.
15) Schematic control diagrams.
16) Instrument loop diagrams.
17) Instrument wiring and piping diagrams.
18) Interconnection wiring diagrams.
19) Cable block diagrams, drawings and schedules.
20) Instrument system and panel power distribution diagrams.
21) Programmable-device functional design specifications which shall include hardware details, control philosophy, logic flow charts, ladder diagrams and program listings.
22) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
23) Labelling & tag schedules.
24) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.
25) All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.
26) Control room, RIO Room interior design layouts, interior design diagrams, control room wiring layout, access control point diagrams, etc.

27) Data and calculations
28) Manufacturers' catalogues and data sheets.
29) Calculations to support control system design.
30) Specification for protective coatings and painting.
31) Certificates
32) Manufacturers' works tests.
33) Pre-installation checks.
34) Pressure-testing schedules.
35) Instrument loop test check sheets.
36) Installed instrument performance tests.
37) System tests.
38) Statutory certificates of compliance (such as hazardous area equipment).

Note: The Contractor shall submit and obtain approval of the FDS from the Employer Representative before beginning procurement. The contractor should take note of the importance of this obligation.

7.7 Design Requirements for Instrumentation, Control & Automation system

Minimum Design Consideration

The instrumentation, control & automation system shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than ten (10) years.

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:
  - use the systems;
  - service the systems;
- to measure, indicate, process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of 'operations and maintenance' personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
  - the most efficient operation of the plant;
  - the routine maintenance of the plant

Equipment and system shall be designed and constructed to perform accurately and safely under the environmental and operating conditions described or implied in this specification without undue heating, vibration, wear, corrosion.

Equipment and systems shall be supplied as per the vendor list indicated in specification elsewhere.

The equipment, systems and accessories furnished shall be designed and constructed to meet the performance specification during the continuous service life of the plant.
Contractor shall indicate the year in which the offered models of the instruments and control system have been introduced and how long the commercial production of the same is expected to continue. In any case, Contractor shall ensure supply of spare parts for minimum period of ten years. In case if it is felt by Contractor that certain equipment/ component is likely to become obsolete, Contractor shall clearly bring it to the notice of Employer and indicate step proposed to deal with such obsolescence like maintaining "bonded spares" with the manufacturer/s.

Any part/ module of the C&I system which are not listed under recommended spares shall be deemed as having life expectancy not less than ten years.

Contractor shall supply proven latest version of hardware and software available at the time of system designing. In case of future up-gradation of software, Contractor shall remain committed to upgrade the supplied system at per with the new version within the warranty period and O&M period and ensure successful integration of the system.

For the sake of completeness of the system and in order to ensure desired performance & safety measures, any hardware or software item felt required, shall be in the scope of Contractor irrespective of their explicit or implicit inclusion in the accompanying document.
Technical details furnished in the accompanying documents are subject to change in future within reasonable limits, which Contractor shall abide by.

7.8 General Technical Requirements

7.8.1 Local Instruments

Required local instruments including gauge boards, level indicators etc. shall be provided.

7.8.2 Cabling Concept

Instrumentation cables shall be copper, overall screened unless manufacturer's recommendation dictates use of pair or triad shields apart from overall shield. All cables shall generally be armoured, other than short run cables which may be unarmoured. Unarmoured cables shall run through conduits.

Binary and analog signals shall not run through the same cable. Signals of different voltage levels shall not be routed through the same cable. The screen shall be grounded at the control room end only.

Conductor cross section for single pair or triad signal cables shall not have individual conductor cross section below 1.5 mm^2 and multi-pair or multi-triad cables shall not have individual conductor cross section below 0.5 mm^2. For solenoid valves, depending on pick-up VA, individual conductor cross section shall not be below 2.5 mm^2. For interposing relay drive connection individual conductor cross section shall not be below 1.5 mm^2.

7.8.3 Design Criteria

This section lays down the general design criteria to be adapted in designing the instrumentation and control system

7.8.4 General Requirements

Instrumentation and control devices and accessories shall be designed with the following considerations:

a) Stable in spite of temperature fluctuations.
b) Able to withstand high humidity.
c) Weather proof.
d) Dust proof.
e) Corrosion resistant.
f) Erosion resistant.
g) Able to withstand high vibration.
h) Entire control System for the plant shall be designed for complete auto mode of operation with all operational interlocks required.
i) Easily accessible for operation & maintenance.

Parts subject to high pressure, temperature or other severe duty shall be of materials and construction suitable for the service conditions and long operating life.

7.8.5 Instrument Accuracy, Standard Scales and Ranges

7.8.5.1 Instrument Accuracy

Instruments shall meet the following general requirements.

a) Pressure measurement shall be linear with respect to the measured pressure.
b) Flow meter shall meet the specified accuracy criteria when operating between 25 and 100 % of full-scale flow. The accuracy shall include the effect of errors in the differential head measuring device, square root converter and signal generator.
c) Level measurement shall be linear with respect to the measured level based on a water specific gravity of 1.00.

7.8.5.2 Instrument Scale Displays

a) All displays shall be in engineering units. Instrument scales displayed on screen will have graduations with scale divisions based on multiples of 10. The smallest division shall preferably be a whole number approximately 1% of the scale range if not otherwise impracticable.
b) Pressure instrument shall have the unit suffixed with ‘a’ or ‘g’ to indicate absolute or gauge pressure, respectively.
c) Scales and charts of all instruments shall have linear graduations

7.8.5.3 Instrument Ranges

Instrument range shall be selected to have the normal reading, preferably between 50% and 70% of full scale for linear parameters and 70% to 80% for flow measurements. Deviation indicators shall have the null position at midscale. The normal operating parameter shall be identified with a clear green mark.

7.8.6 Established Reliability & Availability of individual instrument system

The target reliability of each component/module shall be established by taking into consideration its Mean time between failure (MTBF) and Mean time to repair (MTTR), so that availability of each system is assured for 99.7% of the time.

In order to establish the target reliability Contractor shall perform necessary availability tests. Surge protection for solid state systems, selection of proper materials, manufacturing processes, quality

controlled components and parts, adequate derating of electronic components and parts shall be ensured to meet the reliability and life expectancy goals.

Continuous self-checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.

7.8.7 Measurement & Channel Redundancy

To meet the failure and self- checking criteria for the control system, measurement redundancy shall be provided for all the critical parameters. Throughout the control system, the security and validity of signals are to be ensured based on the following design principles.

a) Where a plant measurement is to be duplicated or triplicated such signals shall be separately fed to the different input modules.
b) Signals, after due security and validity checking by means of voting, averaging, median, difference monitoring or similar technique shall be used for control functions.
c) Where duplicated measurements are used, provision shall be there for selecting any one as the duty signal. Continuous monitoring of difference between the signals shall be made.
d) Signals shall be verified against cable failure.

7.8.8 Design of Enclosures

Design of outdoor enclosures shall be weather proof-(IP-65), dust-tight, drip-proof and shall take into account the environmental conditions.

Enclosures shall be adequately sized so that the maximum permissible temperature rise above ambient is 10 ^{O}C (maximum).

Enclosures design shall also take into account greatest possible personnel safety.

All instrumentation, inclusive of the analytical instrumentation, shall be mounted inside the IP-65 rated enclosures, irrespective of the transmitter IP rating.

7.8.9 Electrical Noise Control

Equipment furnished by Contractor shall incorporate necessary techniques to eliminate problems caused by electrical noise interferences and power line borne surges encountered in power plant environment. Equipment, which is vulnerable to electrical noise interference or surge, shall be suitably immunized to eliminate possible problems.

7.8.10 Surge-Protection for Solid State Equipment

All solid-state equipment shall be able to withstand the surges inherent in a working environment. Equipment shall be designed to successfully withstand surges without damage to components and/or wiring on application of surge wave whose shape and characteristics are defined in ANSI publication C37.90-a (IEEE-472-1974) entitled "Guide for Surge Withstand Capability (SWC) Tests".

To immunize the system against surge, coupling free- wheeling diodes, surge suppressors, optical / galvanic isolators shall be used as required.

7.8.11 Panels, Cubicles and Enclosures

7.8.11.1 General

a) All panels, cubicles and enclosures shall be furnished complete with integral piping, internal wiring, convenience outlets, internal lighting, grounding, ventilation, space heating, vibration isolating pads and other accessories.
b) Unless otherwise specified cable entry for panels / desks / cabinets shall be through bottom via glanding plate. Fireproof seal shall be used to seal the bottom to prevent entry of dust.
c) Panels and cabinets shall be constructed from steel sheet reinforced as required to provide true surface and adequate support for devices mounted thereon. Thickness of the steel plate shall conform to the requirements of UL 50 or equivalent standard. Panels and cabinets shall be of adequate strength to support mounted components during shipment and to support a concentrated load of 100 Kilograms on their top after erection.
d) Panel/ cabinet shall have eyebolt on top for lifting.

7.8.11.2 Surface Preparation and Painting

Sheet metal exterior steel surfaces shall be sand blasted, ground smooth and painted as specified below:

Suitable filler shall be applied to all pits, blemishes and voids in the surface. The filler shall be sanded so that surfaces are level and flat; corners are smooth and even. Exposed raw metal edges shall be ground burr-free. The entire surface shall be blast clean to remove rust and scale. Oil, grease and salts etc. shall be removed from by one or more solvent cleaning methods prior to blasting.

a) Two spray coats of epoxy primer surfacer shall be applied to all exterior and interior surfaces, each coat of primer surfacer shall be of dry film thickness of 1.5 mil. A minimum of two spray coats of final finish color (Catalyzed epoxy or polyurethane) shall be applied to all surface of dry film thickness 2.0 Mil. The finish colors for exterior and interior surfaces shall conform to the following shades:

i. Exterior – RAL 7032
ii. Interior - Brilliant White.

b) Paint films, which show sags, cheeks, blisters, teardrops, fat edges or other painting imperfections shall not be acceptable.

7.8.11.3 Wiring

Wiring within the panels shall conform to NEC standards and shall be factory installed and tested at the works. All interior wiring shall be installed neatly. Features shall not be limited to the following :

a) All spare contacts of relays, switches and push buttons shall be wired up to the terminal blocks.
b) Each wire shall be identified at both ends with wire designation as per approved wiring diagram. Heat shrinkable type ferrules with indelible computerized print shall be used with cross- identification.
c) Wire termination shall be made with insulated sleeve and crimping type lugs. All external connections shall be made with one wire per terminal. Wire shall not be spliced or tapped between terminals. Open-ended terminal lugs shall not be used.
d) Internal wiring should be terminated uniformly on one side of the terminal block leaving the other side available for termination of outgoing cables.
e) Analyzer measuring lead wires, or any other lead wires carrying measuring signal of the order of low millivolt or micro volt shall be electrically and physically isolated from other AC and DC wiring.
f) All low-level signal cables shall be separately bundled from control cable.
g) Wires shall be dressed and run in troughs with clamp-on type covers. Wirings shall be neatly bunched in groups by non-metallic cleats or bands. Each group shall be adequately supported along its run to prevent sagging or strain on termination.
h) Shield wires shall be terminated on separately.

i) Common connections shall be limited to two wires per terminal.
j) Wiring to door mounted devices shall be provided with multi-strand wires of (49 strands minimum) adequate loop lengths of hinge-wire so that multiple door openings will not cause fatigue to the conductor.
k) Wiring shall be arranged to enable instruments or devices to be removed and/or serviced without disturbing the wiring. No wire shall be routed across the face or rear of any device in a manner, which will impede the opening of covers or obstruct access to leads, terminals or devices.
l) Panel internal wiring shall follow distinct color-coding to segregate different voltage levels viz. 24V DC, 48V, 110V AC, 240V AC, 220V DC etc.
m) Panels/ cabinets/ desks shall be provided with removable gasketted cable gland plates and cable glands. Split type grommets shall be used for prefab cables.
n) Wire shall be multistranded annealed flexible high purity copper conductor with heat resistant FRLS PVC insulation and shall pass vertical flame test per IPCEAS-1981.
o) Wire sizes used for internal wiring shall not be lower than the followings :

i. Control wiring (switchs, pushbuttons etc.)	:	1.5 Sq.mm
ii. Power supply/ receptacle illumination wiring	:	2.5 sq. mm or higher as per load.
iii. 4-20mA DC current and low voltage signal up to 48V DC	:	1 Sq. mm

p) Identification of conductors shall be done by insulation color-coding identified on drawings or by printed wiring lists.
q) All cables terminated in the terminal block (both signal cables and power cables) shall be ferruled. Ferruling shall be double cross ferruling, i.e., source and destination addresses shall be marked on both sides of the tube ferruling.

7.8.11.4 Grounding

a) System cabinet AC and DC ground shall be electrically isolated from each other and also electrically isolated from the Instrumentation signal ground. All the above ground shall be individually connected to the single point on the ground pit. Dedicated redundant earth pit shall be provided which shall be away from the HV equipment. This earth pit shall not be shared with other electrical equipment ground and shall also be insulated from other electrical system ground to ensure single point grounding of the system. Grounding resistance shall be better than 1.0 ohm. IEEE guideline shall be followed while designing the grounding system.
b) Panels and cabinets shall be provided with a continuous tinned copper ground bus bar of minimum 25 mm x 6 mm cross section, extending along the entire length of the panel / desk / cabinet assembly. The ground bus shall be bolted to the panel structure and effectively ground the entire structure.
c) The panel/ desk/ enclosure/ JB ground shall have two (2) bolt drilling with GI bolts and nuts at each end to connect to GI/ copper flat ground riser by means of insulated copper ground cable of required cross section with lug.
d) Circuits requiring grounding shall be individually and directly connected to the panel ground bus.
e) For electronic system cabinets, the electronic system ground bus shall be similar but insulated from the cabinet and shall be separately connected to the system ground. Signal cable shields shall be grounded at the panel end only and shall not be left open. The ground in between panels of a shipping section shall be firmly looped.
f) Electrical meters, relays, transmitters and switching devices, operating at a voltage less than 50V may be grounded through the steel structure.

7.8.11.5 Panel / Cabinet/ Desk/ Enclosures Environmental Protections

a) Panels, cabinets, desks, distribution boxes, terminal boxes and all other field mounted equipment / enclosures shall suit the environmental condition of the area and shall not Be inferior to the requirement indicated in the following table:

Sr. No.	Location	Enclosure type
1.	Indoor type non- ventilated enclosure in non-hazardous area	IP-45
2.	Indoor type ventilated enclosure in non-hazardous area	IP -42
3.	Enclosure in Air conditioned area	IP-22 with suitable canopy at top to prevent ingress of dripping water.
4.	Outdoor type in non-hazardous areas	IP-65
6.	Outdoor in hazardous areas	As per requirements of the NEC / IS Code for the location

b) The construction of electrical enclosures located in areas subject to conditions classified in the National Electrical Code (NEC)/IS Code as hazardous shall be of a type designated suitable for the environment in which they are located.

7.8.11.6 Terminal Blocks

a) Terminals shall be chromated galvanized DIN rail mounted screwless cage clamp type. Terminals shall have screwed connection for conductor cross-section above 2.5 mm2. Terminal blocks shall conform to IEC 947-7-1.
b) The characteristics of the terminal blocks shall be as follows.
i. High contact force, independent of conductor cross-section and large contact surface area.
ii. Self-loosening protection.
iii. Resistant to thermal aging and vibration.
iv. Low and constant voltage drop
c) Tension spring shall be made of high quality, non-rusting, acid-resistant steel. The current bar shall be of tin-lead plated copper or brass.
d) Terminals shall be of non-flammable suitable thermoplastic material such as polyamide.
e) Terminal blocks shall be mounted vertically in panels and cubicles with clearance for at least 100 mm between two sets and between wall and terminal block.
f) Terminal blocks shall be provided with white marking strips / self-adhesive marker cards. Power terminals shall have protection covers.
g) At least 30 percent spare unwired terminals shall be provided for all panels /cabinets /desks /junction box etc. This shall be in addition to 20% spare wired terminals of spare IO channels and 10% wired spare modules.
h) Bottom of the terminal block shall be at least 200 mm above the cable gland plate for bottom entry type panels.
i) For extending 24 V DC supply to panels, the size of the terminals shall be decided based on voltage drop and not based on current.
j) Other requirements of the terminal blocks are as follows.
k) The last block in a rail-mounted assembly shall be closed with an end plate and end bracket.
l) For visual and electrical separation of terminal groups, partition plates shall be provided,
m) which can be push fitted after forming an assembly.

n) Design shall permit testing of incoming and outgoing signals by using suitable test plug and socket without disconnecting the cable connections.
o) It shall be possible to use jumper plugs through the test plug socket to connect adjacent
p) terminals.
q) Where more than one connection to a terminal block is required, two tier terminals shall be used.
r) Terminal blocks shall be of different colors depending on voltage levels.

7.8.11.7 Nameplates and Labels

a) Each item shall have permanently attached to it, in a prominent position, a rating plate of non-corrosive material upon which is to be engraved the, equipment, type / model number, range, serial number, together with details of the loading conditions under which the item of plant in question has been designed to operate.
b) Such nameplates or labels are to be of white non-hygroscopic material with engraved black lettering, or alternatively of transparent plastic material with suitably colored lettering engraved on the back.
c) The nameplates shall be held by self-tapping screws. The size of nameplate shall be approximately 20 mm x 75 mm for equipment and 40 mm x 150 mm for the panels.
d) Items of plant such as valves, which are subject to handling, are to be provided with an engraved chromium plated nameplate or label with engraving filled with enamel, suitably mounted or as fixed with strong rustproof chain.
e) All such nameplates, instruction plates, lubrication charts etc. shall be with English inscriptions.

7.9 Metering Bases And Chart Units

The following system of units shall be followed for various displays and scales unless otherwise mentioned:

i)	Pressure	:	Kg/cm^2
ii)	Differential Pressure	:	mm of H_2O column / Kg/cm^2
iii)	Draught	:	mm of H_2O column
iv)	Vacuum	:	Kg/cm^2 (abs)/ mm of Hg column
v)	Temperature	:	Degree Celsius (^{O} C)
vi)	Flow (Water)	:	Tonnes / hr, M^3/Hr
vii)	Flow (Oil)	:	M^3 / Hr, Liter/ Hr
viii)	Flow Air	:	Tonnes / hr / M^3 / Hr.
ix)	Density	:	gms / c.c.
x)	Level	:	Mm /%
xi)	Conductivity	:	Siemens / cm
xii)	Dissolved Oxygen / Silica / Sodium	:	ppm /ppb
xiii)	Turbidity	:	NTU
xiv)	Residual Chlorine	:	ppm
xv)	UV Transmittance	:	%

7.10 Process Connection & Instrument Hook Up

Instrument connection to the process system (piping, vessel etc.) shall be according to the process & piping specification up to and including the root valves. Root valves shall be installed as close as possible to the piping or vessel.
Each instrument shall have its own independent connection to the process except for instruments located on standpipe. Each instrument shall be connected independently to the standpipe through isolation valve.

Isolation and drain valves adequate for duty and capable of withstanding continuous design condition of main process shall be provided. For process pressure equal or above 40 kg/ sq.cm double blowdown

valves shall be used connecting to blowdown header. Instrument manifold / gauge valve shall be installed close to the instrument.

Process connection for instruments lines and vessels shall be in accordance to standards such as ASME or other recognized international standards. Table below indicates the type of connection generally to be used.

Instruments	Equipment / Pipe Side	Instrument Side
Level Instruments		
Internal Displacer	4" - Flanged	4" - Flanged
External Displacer	2" - Flanged	2" - Flanged
Level gauge	¾" -Flanged	¾" - Flanged
DP Type	½" (min.)-welded	½"- NPT
External cage Level switch	1"- welded	1"- welded
Flow Instruments		
DP Type	½" - welded in general	½" - NPT
Pressure Instruments		
Conventional	½" (min.)-welded	½" - NPT
Diaphragm type- Fuel Oil application	3"- Flanged	3"- Flanged
Temperature Instruments		
Thermowell	Generally - M 33 X2 (M) 1½" Flanged- For air path application	½" NPT
Analyzer		
Liquid analyzer	½"- 1" - welded	½"

Separate stubs and take-off points with thermowell / root valves shall be provided for performance guarantee test.

Impulse pipes shall be clamped at suitable interval not exceeding 1.5 meter. Process pipe shall not be used for supporting the impulse pipe.

Fittings shall conform to ANSI B 16.11. Threads of piping component shall be of tapered construction.

Instrument blowdown header shall in no case be lower than the material grade ASTM A 106 Gr. C.

Impulse pipe shall be laid at least with slope of gradient 1:10 to avoid any air pocket or water accumulation.

Expansion loop shall be provided at the end of each termination.

Orientation of tappings shall be as follows:

a) For liquid service within 45 ^{O} at lower half of the pipe horizontal plane.
b) For air service within 90 ^{O} at upper half of the pipe horizontal plane.

As a rule tap orientation of high and low pressure side should be parallel and symmetrical.

Pressure & Differential pressure instruments in liquid services shall be located below the taps and the piping shall be sloped to avoid formation of air pocket.

Pressure & Differential pressure instruments in air service shall be located above the taps and the piping shall be sloped back to process to avoid formation of any liquid.

Impulse pipe including taps for coal mill application shall be provided with air purge connection. Differential instruments for such application shall have continuous and as well as intermittent purging. Whereas, pressure measurement shall have only intermittent purging.

Material of impulse pipe for the instruments mounted on rack and enclosure shall be same as that of main process pipe except stainless steel tube of Gr. 316H or better shall be provided for connection in between impulse pipe (from tee connection on impulse pipe) and instrument manifold valve & instruments. Impulse pipe, tubes, fittings and accessories shall have the same design pressure and temperature applicable for the related main pipe.

A. Site Conditions

- Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (noncondensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.
- EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.
- Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1or equivalent Indian Standard for noise emissions.
- Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
- Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

B. Panel Details

I. Enclosures and mounting boards

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

Enclosures mounted inside buildings shall have a minimum rating of protection to IP 45.
Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

All instrumentation, inclusive of analytical instruments (DO, ORP, Chlorine, Multi parameter online instruments, etc..) irrespective of the transmitter IP Rating shall be installed in IP-65 rated enclosures.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

II. Panel design and construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level. All panels shall have a minimum width of 900 mm and shall not exceed 2mtr in length in any case

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

III. Panels - Major

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 3mm as a minimum.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All panels shall have a minimum width of 900 mm and shall not exceed 2mtr in length in any case. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A chequer- plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.
Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.
All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

IV. Panels – Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel less than 3 mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids,

moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.
The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

V. Panel Protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 20% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.
At least 30%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

VI. Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the ‘off’ position. The ‘on’ and ‘off’ positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.
Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

VII. Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analyzers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the clippon type SAKC or equivalent which permit the connection of a test millimeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 20% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalised where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimise the risk of accidental contact.

VIII. Panel internal wiring

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):
1.1 ac power supplies;
1.2 dc power supplies;
1.3 ac current signals above 50mA (such as CT circuits);
1.4 ac voltage and control signals above 50V (such as PT circuits).

Group 2: High-level signal wiring (6V to 50Vdc):
2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);
2.2 circuits to alarm annunciators and other solid-state devices
2.3 digital signals;
2.4 emergency shut-down and tripping circuits;
2.5 on/off control circuits;
2.6 intrinsically safe circuits;

Group 3: Low-level signal wiring (5V dc and below):
3.1 signals from thermocouples;
3.2 signals from resistance thermometers and re-transmitting slide-wires;
3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

(a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;

(b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved insulated wiring trunking or non-corrodible flexible tubing. Not more than **75%** of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

IX. Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling. Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

X. Panel Earthing

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armoring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

XI. Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed LED lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

XII. Panel ventilation

Each panel shall be provided with ventilation fans to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

XIII. Panel labels

All control gear shall be fully labelled, identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Employer Representative before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, minimum 4mm high.

The minimum practicable number of different sizes shall be used.
Note: Contractor shall note that Manufacturers' nameplates shall not be fitted on panel external surfaces. Only equipment Tag I.D shall be located on the panel exterior surface. The same is applicable for filed junction boxes, panels, enclosures, etc.

XIV. Panel finish

All panels, desks and cubicles shall be hard, smooth, durable and finish free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Employer Representative. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard.

C. Instruments and ancillaries

I. General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalized and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where

applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 100mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1or equivalent.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance. Access platform shall be provided for all instruments which shall be mounted at a height to enable plant operators to access the same for reading and maintenance purposes.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof IP-65 enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

a) Kilowatt-hour meters.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy (±2.5%). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

Quantity : 1 No. for each pump and incomers of 3.3 kV (or more)
Switchboard (250 KW & above motors)
As per site conditions.
Purpose: Power and Energy Monitoring

It shall monitor voltage, current, kW, kVAr, kVA, power factor and frequency. The data of these meters shall be communicated to the plant PLC based SCADA system for monitoring.

Technical Particulars

Data logging
Data storage and it shall be retrieved via RS 485 port

Soft Integration
The meter shall be integrated with SCADA system to provide remote display of all measured parameters and meter configurations. The metering shall be via. RS 485 port.

Measurement
- True RMS measurement
- Instantaneous phase voltages, line voltages, phase currents and line currents
- Frequency
- Active, reactive, apparent powers and power factor per phase and line
- Energy-Import and Export
- Maximum demand kVA, kW, kVAr

Communications
- RS 485
- Baud rates minimum 9600

Accuracy Class
- 0.5 S

Accuracy Standards
- IS-14697:1999

Front Panel Display
- LCD with back lighting
- Display for all basic power and energy parameters
- Password protection for setup parameters

Ratings

Voltage Inputs
- 50 to 347 VAC

- Accuracy VL-N: 0.25% reading
- Accuracy Hz : +/- 0.1 Hz
- Support 3 phase 3 wire, 3 phase 4 wire connections
- Standard screw in terminals

Current Inputs

- 5 Amp. nominal
- Accuracy current: 0.25% reading
- 20% over range full accuracy

Power Supply

- 110 V to 240 VAC & VDC

Environmental Conditions

- As per process Requirement- Ambient Temperature.
- Humidity: up to 95% noncondensing

II. Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring. Lamp holders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

- power on - white*
- running - green
- tripped/alarm - red
- status (open, closed, etc.) - blue
- ready to start - blue
- warning (no imminent danger) - amber

Note: *white may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

III. Pushbuttons

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

- stop, emergency stop - red
- start - green
- jogging/inching - black
- reset (when not also acting as a stop) - blue
- lamp test - blue
- override/alarm accept - yellow

D. Junction Boxes

I. Junction box (Instrument)

1	Construction	-	UV resistance plastic
2	Protection	-	IP 65
3	Paint and shade	-	
			Powder coated light grey as per
			Shade 631 of is:5
4	Terminal strip	-	Elmex type capable of
			Terminating 0.5 sqmm to 1.5 sqmm
			Cable din rail mounted
5	No of terminal strips	-	30/40/70
			Rating:600v 10 a ac
6	Conduit & cable entry	-	Bottom side
7	Gland plant thickness	-	3mm
8	Door of JB	-	Hinged with proper locking
			Arrangement to avoid entry of
			Dust & moisture the design of
			Fixing screws of the lids of the
			Junction box shall be such that
			They do not come out of the lids
			When completely unscrewed
			(captive screws)
9	Dimension	-	Vendor to provide most
			Economic dimension of JB based
			On the no of Terminal bases and cable
			Entry
10	Mounting	-	Frame mounted
11	Earthing	-	Two no of earthing bolts for JB
			Earthing separate instrument
			Earth bus on insulating clits to
			be provided
12	Name plates	-	To be provided material: white
			Engraved letters on black
			Anodized aluminum sheet
			Fixing: stainless steel screws
			Lettering:- black with white
			Engraved. Note: No vendor nameplate shall be affixed to the junction box(exterior, interior)

II. Junction box (power & control)

1	Construction	-	UV resistance plastic
2	Protection	-	IP 65
3	Paint and shade	-	Power coated light grey as per
			Shade 631 of IS:5
4	Terminal strip	-	Elmex type capable of
			Terminating 0.5 sqmm to 1.5 sqmm
			Cable din rail mounted
5	No of terminal strips	-	30/40/70
6	Conduit & cable entry	-	Lower side
7	Gland plate thickness	-	3mm
8	Door of JB	-	Hinged with proper locking
			Arrangement to avoid entry of
			Dust & moisture the design of
			Fixing screws of the lids of the
			Junction box shall be such that
			They do not come out of the lid
			When completely unscrewed
			(captive screws)
9	Dimension	-	Vendor to provide most
			Economic dimension of JB based
			On the no of Terminal bases and cable
			Entry clearly specifying GA
			Drawing
10	Mounting	-	Frame mounted
11	Earthing	-	Two no of earthling bolts for JB
			Earthing
12	Name plates	-	To be provided material: white
			Engraved letters on black
			Anodized aluminum sheet
			Fixing: stainless steel screws
			Lettering:- black with white Engraved. Note: No vendor nameplate shall be affixed to the junction box(exterior, interior)

E. Cabling

I. Instrumentation Cabling

Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the

satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analyzers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

II. Fiber Optic Cable

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

a) Type of fiber
b) Ambient conditions
c) Method of installation
d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the engineer as follows:

- Submit full technical details of each type of cable proposed.
- Submit copy of test certificates from the manufacturer
- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Employer Representative upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Employer Representative for examination and approval.

All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Employer Representative.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 6 fibers, loose tube, two fibers per tube with central 1.5 mm nominal steel central strength member, moister barrier, steel tape armored in continuous lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

Single Mode	
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)
Multimode	
Type of fiber	Multimode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 $\pm$ 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 MHz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

III. Cable Termination Boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the engineer.
Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomatic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

IV. Cable labelling

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.
a) Power terminations - colour, number or letter.
b) Control terminations - letter or number or both.

V. Cable terminations

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of 4mm² or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Employer Representative prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

VI. Cable installation-general

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Employer Representative, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Employer Representative.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as rawplugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and

fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

VII. Drawings and schedules:

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
- Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;
- The position of all marker posts, joints, draw pits and the like.
- Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

VIII. Data and calculations:

Manufacturers' catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

IX. Test certificates:

Test certificates for all witnessed and routine tests carried out at the manufacturer's works and at Site (calibration).

X. Cable trays and ladders

Cable tray, cable trays covers and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the engineer.

Cable tray and ladder systems shall be installed with joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

All instrumentation cables shall be laid in separate cable tray with covers.

XI. Flexible conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible

conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

XII. PVC conduit

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as described for steel conduit.
PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between −5°C and +60°C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilize steel insert clips.

F. Cable installation methods

I. General

All cabling installation methods shall be subject to the approval of the Employer Representative.

II. Installation directly into the ground

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted

sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.

ICA and communication cables shall be laid not closer than 1000mm to high voltage cables.

A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

III. Installation in underground ducts

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:
- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of draw pits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- PVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers.

Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

IV. Sealing cable entries into buildings

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Employer Representative. The stopper shall have a fire resistance of at least 30 minutes.

V. Marking of underground cables

The location of all underground cables shall be identified by:
- cast iron material plates with standard or custom design fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed cast iron material plates with standard or custom design. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Employer Representative.

VI. Installation in cable trunking

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 25% spare capacity. Trunking shall have minimum dimensions of 50mm x 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the manufacturer and of a matching design to the main trunking.
Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Employer Representative before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

VII. Installation in troughs and trenches

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Employer Representative, together with proprietary cable cleats.

VIII. Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.
Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

IX. Cable installation in conduits

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes

shall be of the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.

Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.
Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

7.11 Process Instrumentation

7.11.1 General

- Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

- All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

- All instruments shall be from the country of origin as indicated in the vendor list elsewhere in this specification.

- All instruments ,inclusive of the field instrumentation,(Flow meters, pressure gauges, transmitters, level instrumentation, temperature instrumentation, analytical instrumentation analyzers (DO, ORP, Chlorine, Multi parameters, Auto samplers, etc) shall be offered for inspection & testing before dispatch, at Manufacturers Factory works where the instrument has been manufactured. The same shall be indicated in the QAP and submitted along with the equipment datasheet for review and approval.

- Electronic instruments shall utilise solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

- No custom made hybrid type integrated circuits shall be used.

- Unless otherwise stated, overall accuracy of all measurement systems shall be ±0.5 % of measured value, and repeatability shall be ±0.5%.

- Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

- On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

- The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

- Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65.

- All outdoor instruments shall be fitted with IP65 enclosure to shield the instruments against the weather, irrespective of the IP rating of the instrument/transmitter.The enclosures shall be of lockable type.
- The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.

- All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.

- All coated parts of sensors shall be made out of noncorrosive material capable of working with chlorine content of 5 ppm.

- For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

- Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

7.11.2 Flow Measuring Systems

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter.

Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground pipelines.
To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide 4-20 mA dc output proportional to flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least ± 0.5 % of the measured value unless otherwise stated.

7.11.3 Open Channel Flow meter

Open channel flow measuring systems shall consist of level transducer, flow computer and flow transmitter. The level of the fluid in the flume shall be measured by the ultrasonic level transducer. The level measured shall be used along with the physical characteristics of the flume to compute the flow rate.

The level transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP67. It shall have ambient temperature compensation and adjustable datum setting facilities.

The design and application of ultrasonic level meters shall take into account the channel construction, the material size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

The structure required for supporting the level sensor, access platform, railings etc. shall be in the Contractor's scope.

7.11.4 Electromagnetic Flow Meter (Full Bore):

The Electromagnetic Flow Meters shall be installed in RCC chambers for indication of flow rate and totalized reading in a transmission or distribution pipe work of system. The Electromagnetic Flow Meters shall withstand maximum working temperature and working pressure shall be as per process requirement.

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, Flow Integrator and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and pressure rating shall be as per process requirement to be constructed as follows

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter. The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20 mA output .The microprocessor based signal converter shall have a self-diagnostic test mode and backlit display that continuously displays 'Rate of Flow' and 'Total Volume'.

The converter shall be compatible with Microsoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum up to 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

The converter cum transmitter shall be fully programmable from the front facia.

The programming shall be user friendly, self-prompting menu driven.
The length of the sensor shall be strictly as per ISO up to DN 600 mm and for other sizes it shall be as per the manufacturer's standard.

All flow meters(applicable for all sizes of meters) shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration (five point) at the manufacturer factory.

I. Level Measuring System

a) Ultrasonic Level Meters

Ultrasonic level measuring devices applied for liquid level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 67. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be ±0.25% or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

All instruments shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration at the manufacturer factory.

b) Conductivity Level Switches

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP 52 for indoor locations or IP 65 for outdoor locations.

All instruments shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration at the manufacturer factory.

II. Pressure gauges, Switches and transmitters

Pressure gauges shall comply with BS EN 837- Parts 1, 2 and 3. Pressure gauges, transmitters and switches shall have over range protection up to 1.5 times the maximum anticipated line pressure and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span.

Pressure transmitters/switches shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

Pressure gauges, switches and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

Pressure and differential pressure switches shall have contacts with separate 'cut in' and 'cut out' pressure values.

The nominal pressure values at which pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value(s) shall be clearly indicated by means of a scale and pointer.

Pressure monitoring shall be by a sensor suitable for the medium and pressure/level range.

The sensor shall be suitable for either free wire suspension in the medium or fitted remotely and provided with threaded sockets to permit connection of pressure pipework.

A transmitter shall be provided either integral with the transducer or separately mounted and converting the signals received from the transducer to a 4 to 20 mA signal proportional to the range specified.

The transmitter shall have provision for span and zero adjustment.

III. Strain-gauge pressure transducers and transmitters

Strain-gauge pressure transducers shall use thin film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- accuracy: ± 0.1% of calibrated span, including linearity hysteresis and repeatability;
- repeatability: ± 0.05% at maximum span;
- stability: ± 0.1% of upper range limit over 6−month period;
- over pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- power supply variation effect: 0.01% per volt variation.
- load variation effect: ±0.0002% per ohm of loop-resistance variation.
- temperature: −29°C to +82°C range; total thermal error of ±0.75% of span over 0°C to 50°C;
- protection: IP 65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

All instruments shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration at the manufacturer factory.

IV. Temperature Instrumentation

- Resistance Thermometers

Platinum resistance thermometers shall be used for temperature sensing up to 650 Degree C.

Each temperature sensor, used for process monitoring shall have a stainless steel pocket and extension assembly, non-corrodible metal sheath and waterproof terminal head. Pockets for steam, oil and pressurised water lines shall be welded; pockets for other duties shall be screwed. Temperature sensors incorporated within motor winding shall be inserted during the winding process to ensure intimacy of contact.

Platinum resistance thermometers shall be selected and used in accordance with BS 1041-3 and shall comply with BS EN 60751. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for three-wire connections between head and amplifier.

Platinum resistance elements shall be fully encapsulated in ceramic, and element and high temperature resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

- Thermocouples

Thermocouples shall be of the mineral insulated type and, unless otherwise specified, shall be of the chromel- alumel (nickel chromium v nickel-aluminium) type. Wires shall not be smaller than 1.0 mm2 and shall be selected and used in accordance with BS 1041-3 and shall comply with BS EN 60584.

Note: All instruments shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration at the manufacturer factory.

V. Analytical Instrumentation

In all cases, the location and housing of the monitor shall take into account the provision of a representative sample to the monitor sensor, the pre-conditioning if any, required prior to the sample's analysis, operator requirements for access, maintenance, calibration, repair and replacement of the monitor or its sensors.

This section covers individual elements to measure and transmit pH and ORP. Transmitters shall convert the sensor measurement to a 4 to 20 mA dc signal capable of transmission into at least a 500 ohm load at 50 V or less. Power supply shall be 240 Vac, 50 Hz. Reference accuracy of the output signal shall be ± 1 percent of measured span or better. Output signal shall be electronically isolated from ground to permit connection to a receiver with a grounded input. Transmitters shall be provided with an indicating scale having at least a 0.1 meter calibrated length. Operating ambient temperature shall be -5 to + 50 degree C or better. Transmitted signals shall be linear with the measured variable excepting pH which shall be linear with pH.

- **Sensor Measurement Principles and Features**:

Each type of sensor shall use the measuring principle and incorporate the features appropriate to it as specified below:

pH and ORP sensors shall measure hydrogen ion activity and oxidation-reduction potential respectively in the process medium. The pH sensor shall consist of a glass measuring electrode, a reference electrode, a solution ground and a temperature sensor for compensation in the transmitter. The reference electrode shall be the non- flowing type with an electrolyte diffusion rate through a non-reactive porous membrane or plug which shall not require electrolyte refill more often than once per year. ORP sensors shall use the same elements specified for pH sensors except that electrode shall be platinum and no temperature compensation is required. pH and ORP sensor assemblies shall incorporate an integrally mounted preamplifier for the measuring electrode. Sensors shall operate over a temperature range of - 5 to + 1000 C or better.

Construction. Transmitter and sensor enclosures shall be rated NEMA 4 unless explosion proof (XP) is specified on the Schedule. Enclosure materials and finish shall be as specified in the Schedule. If not so specified, they may be the manufacturer's standard which is compatible with the corrosivity of the atmosphere normally in contact with the enclosure. All parts of sensors, their assemblies and supporting parts which are wetted by the process medium shall be constructed of stainless steel and/or plastic unless specified otherwise on the Schedule. When specified on the Schedule, pH and ORP assemblies shall be provided with integrally mounted ultrasonic cleaners.

Total Dissolved Oxygen Monitoring System

The Dissolved Oxygen (D.O) monitoring system shall consist of a sensor, transmitter, indicating converter and electrode cleaning equipment. Accuracy shall be $\pm$ 0.5% full scale for DO, barometric pressure $\pm$ 0.27 kPa and temperature $\pm$ 0.3°C.

The sensor shall not require zero point. The transmitter shall allow the DO sensor to be fitted without the use of tools. The transmitter shall output a signal proportional to the DO level and measured temperature. The following alarms shall be detected and transmitted.

1) Membrane puncture
2) Depleted or worn out DO sensor
3) System/electronic fault.

The indicating converter shall perform auto calibration of the system and compensate for sensor age, temperature, barometric pressure, relative humidity and liquid salinity. It shall display OD concentration, temperature, sensor lifetime remaining (mg/l x hours or %) and rh selected for calibration.

Construction: The DO sensor shall consist of a prefabricated, disposable, sealed cartridge that slides easily into the transmitter without special tools. Systems that require re-generation (refill of electrolyte and membrane change) shall not be acceptable. The sensor shall use the Clark's principle, with a gold cathode, silver wire anode and a nontoxic electrolyte of potassium chloride. The pre-stressed membrane shall be of Teflon and bonded onto the DO sensor.

The transmitter shall be protected to IP 67 and supplied with minimum 15 m of cable for connection to a junction box. The converter shall be housed in a NEMA 4 x enclosure and be handrail or panel mounted up to 200m from the sensor without need for a pre-amplifier. It shall be interchangeable without the need for recalibration or reprogramming of the system by using a sensor specific storing device continuing all settings and calibration.

The sensor and transmitter shall be installed in a self- cleaning polystyrene ball float, which shall float on the surface of the water and allow the sensor to be inserted by approximately 125mm into the water. The ball shall be constructed to fit the sensor and transmitter and leave a smooth surface to prevent accumulation of dirt or grease.

Note" All instruments shall be offered for inspection & testing before dispatch at Manufacturers Factory where the instrument has been manufactured. QAP shall be submitted which shall include functional testing and calibration at the manufacturer factory.

7.12 Installation Requirements for Instruments

7.12.1 General

The contractor is responsible for coordinating the installation, testing and commissioning to assure proper interface and system integration. Services shall include, but not necessarily be limited to all labour, materials, tools, equipment, supplies and services and auxiliary devices including brackets and mounting hardware required to install the instrumentation.

7.12.2 The following general installation guidelines shall apply:

- Transmitters and transducers shall be mounted as near as practical to the measurement point. The transmitter shall be installed at a suitable location and height for the operator to view the transmitter display
- Instruments shall be readily and safely accessible from grade, permanent platforms or fixed ladders to facilitate ease of maintenance for the equipment.
- Supply power to instrumentation from the control panel to which information is reported for remote monitoring. Provide a separate (independent) circuit for each analyzer (note that control panels are powered by online UPS and supplied from the sites critical emergency power circuit).
- Unless otherwise shown or specified, all instruments shall be mounted 1.4 m above finished floors, grade or platforms. Allow for cabinet plinth/floor-pad heights when locating panel instruments.
- Do not mount direct reading or electrical transmitters on process piping. Mount on instrument racks or stands or in enclosures near the sensor at a level that permits viewing from ground elevation.
- Do not mount instruments on vibrating structures (e.g. handrails), or on piping or near equipment that may induce vibration.
- Do not mount instruments below or directly adjacent to lines conveying corrosive chemicals or near sources of leakage or spillage.
- Install the instrumentation and auxiliary devices (including sensors) such that they are accessible for maintenance. Provide space between instruments and other equipment and piping for ease of removal and servicing. Install to ensure accessibility from grade without requiring staff to enter confined spaces.
- Ensure that instrument displays are properly oriented for easy viewing.
- Any instrument that is not easily accessible for operation or maintenance, and any indicator that is not easily and readily visible, must be relocated as directed at no charge to the contract.
- Follow additional installation requirements as specified in the individual instrument sections and as recommended by the manufacturer.
- Follow the Manufacturer's recommendations for loading resistors on digital outputs to limit the affect of leakage currents through triac and relay outputs.
- Follow the Manufacturer's recommendations for surge suppression on inductive loads.
- Unless specifically instructed otherwise, ensure installations conform to the manufacturer's installation recommendations.

7.12.3 Analytical Instrumentation

- Physically locate the sample point so is does not contribute unnecessary dead time in the analysis. Take care to ensure the sample point is clean, thoroughly mixed, and representative of the process stream.
- Locate the analyzer next to a floor drain. Provide shutoff (block) and bleed valves: size valve and select type and material for the application.

- Provide flushing facilities for cleaning probes

7.12.4 Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, Zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self- resetting to minimise the down time of the measurement loop.

SPD s shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10 KA.

7.13 Control & Automation

7.13.1 Programmable Logic Controllers

Each STP in this contract shall be provided with PLC based SCADA system.Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring, process control and reporting functions with counter and timer facilities. In particular, there shall be a single vendor for STP under this contractto ensure uniformity among equipment and spare holding.

In particular, the following configuration shall be applicable across the STP.

Plant PLC system shall be a hot standby PLC linked to the plant redundant SCADA system. The process systems shall be furnished with individual RIO panels with 16” color HMI with touch screen functionality, with RIO modules which shall communicate with the main plant PLC for monitoring and control. No separate PLC system for monitoring and control of process system or complete plant control from process system vendor shall be accepted. Contractor shall note the importance of this clause.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;

- it shall scan the inputs in time cycles and update the status of its outputs;

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- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs;

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLCs shall be microprocessor based. PLCs shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC System & all RIO systems should be housed in air conditioned environment.

The contractor shall submit the sizing calculations for the air conditioning system for review and approval. The contractor shall refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

7.13.1.1 Remote input/output modules (RIO)

The PLC system shall consist of field remote input/output modules (RIO) panels. Each RIO panel shall consist of redundant communication modules, power supply modules, minimum 16" color panel mounted HMI with touch screen functionality. It shall be possible to view and acknowledge the alarms and view set points for the particular process from the HMI etc. The HMI shall be configured such that plant operator can view and control the previous and next process sequence from HMI along with the set points. and alarms.

7.13.1.2 I/O Modules:

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Refer the approved vendor list for the PLC system and hardware, elsewhere in this document.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable. Provision shall be provided for future expansion of additional 30% extra I/O modules of the installed capacity in the panel.

I/O modules shall be as follows:

a) Inputs shall be opto isolated;
b) filters shall be provided for noise rejection;
c) output status shall be indicated by an LED;
d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
e) All the modules shall be of addressable type.
f) Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

7.13.2 Ethernet Switches

The contractor shall only provide managed industrial grade Ethernet switches under this contract. Minimum 16 port managed Ethernet switch shall be provided.

7.13.3 PLC Programming

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.

PLC programming under this contract shall be implemented using only functional block diagrams (FBD).

The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

1) Logic functions (such as AND/OR/AND NOT etc.);
2) Timer functions (externally adjustable);
3) Counter functions;
4) Skip functions;
5) Comparison functions;
6) Limit value functions;
7) Arithmetic functions;
8) Physical unit functions;
9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review & approval as an integral part of FDS submissions.

The Contractor shall provide all required IT Hardware complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

7.13.4 Supervisory Control & Data Acquisition System (SCADA) system

Each STP in this contract shall be provided with a dual redundant SCADA system and Historian software.The SCADA shall be suitable for day to day operation by non-computer literate personnel in the

monitoring and operation of the treatment works. . In particular, there shall be a single vendor for all STP's and ISPS under this contract ensure uniformity among SCADA and Historian software's.

SCADA shall be provided at central Monitoring Room which shall be located in administration building.

Each STP shall be provided with a Dual redundant SCADA system. The SCADA software shall be of minimum twenty five thousand tags version. The SCADA System shall be designed to store, archive and retrieve complete plant operational data for at least six (6) months. This shall be provided in addition to the Historian software being provided at each STP.

The Historian software shall be designed and configured on a minimum to accept the number of tags similar to the SCADA software (i.e Ten thousand tags). The Historian software and server system shall be designed and configured to store data for a minimum of seven years.

On a minimum, each STP SCADA system shall generally consist of the following:
1) SCADA software's & licensing as indicated above.
2) SCADA redundant servers
3) Historian software & station as indicated above
4) SCADA Operator work station with licensed SCADA software (inclusive of Latest Windows OS, Anti-Virus software, firewall, required licensed software)
5) SCADA Engineering work station with licensed SCADA software (inclusive of Latest Windows OS, Anti-Virus software, firewall, required licensed software) and 32" LED monitors
6) A3 size all in one printers
7) Managed industrial grade Ethernet switches
8) 65" 1 LED screen which shall act as a mimic for the SCADA system along with required controllers and display system
9) Industrial grade control room console with minimum 5 nos of ergonomically designed seating systems for plant operators and supervisors.
10) File record shelves with glass doors with locking facility (at least two) to store SCADA alarms, records, operator notes, etc.,,,,

The SCADA system shall provide efficient and safe operation of the entire plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers workstation (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, automatic control and operation of the entire plant.

SCADA control room shall be equipped with False flooring & false ceiling. The entire control room shall be provided with air-conditioning systems (at least two nos. of 2 tonne air conditioners in the main control room area).

SCADA control room shall be designed to have maximum view of the plant and plant operation. The brick masonry works in the control room shall be replaced with full length glazed windows.
No UPS system shall be installed in the control room. A separate UPS room with battery room shall be provided in the administration building for the purpose.

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers workstation (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, automatic control and operation of the entire system. The SCADA control room shall be equipped with false flooring to provide access for all cables. No cables shall be installed over the control room floor.

Note: Refer particular specifications for design of SCADA control room and the particular requirements.

7.13.5 Uninterruptible Power Supply (UPS)

The power for entire control system inclusive of SCADA system,Programmable Logic Controllers (PLC) and RIO panels inclusive of all IT hardware, centrifuge PLC & complete field Instrumentation system, Fire alarm system and CCTV system shall be derived from separate redundant UPS system at both STP and ISPS's.

The UPS provided shall be sized to provide power to maintain system functioning for a period of minimum two hours (120 Minutes) on full load, in case of power failure.

The UPS shall be an online UPS, i.e. the status & complete operating parameters of the UPS shall be monitored by the plant SCADA system in real time.

The above feature should be demonstrated during UPS Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

End of Part 7